THE OHIO STATE UNIVERSITY

SLEEP

Lawrence Chan D.O.
Division of Pulmonary, Critical Care and Sleep Medicine


Sleeping in Class
Level: Pro
FunnyBeing.com

- Objectives
- Describe what is sleep and why is it important.
- Describe what happens when we do not sleep enough.
- Describe ways to improve sleep.

Sleep

The natural periodic suspension of consciousness during which the powers of the body are restored

-Merriam Webster

Sleep

Reversible behavioral state of perceptual disengagement from and unresponsiveness to the environment

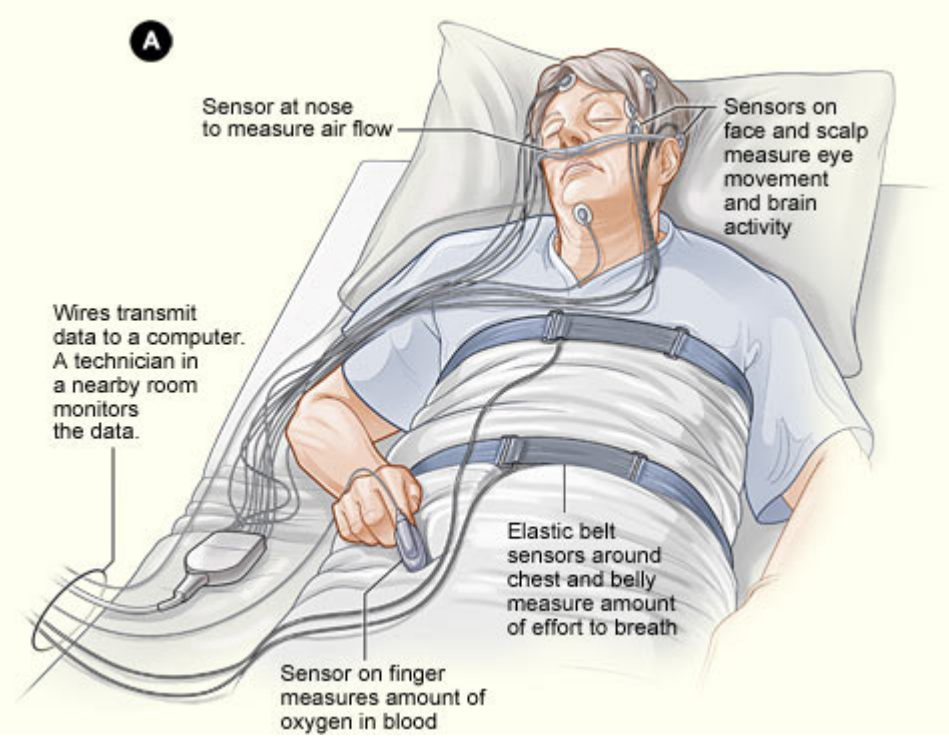
-Principles and Practice of Sleep Medicine

Behavioral

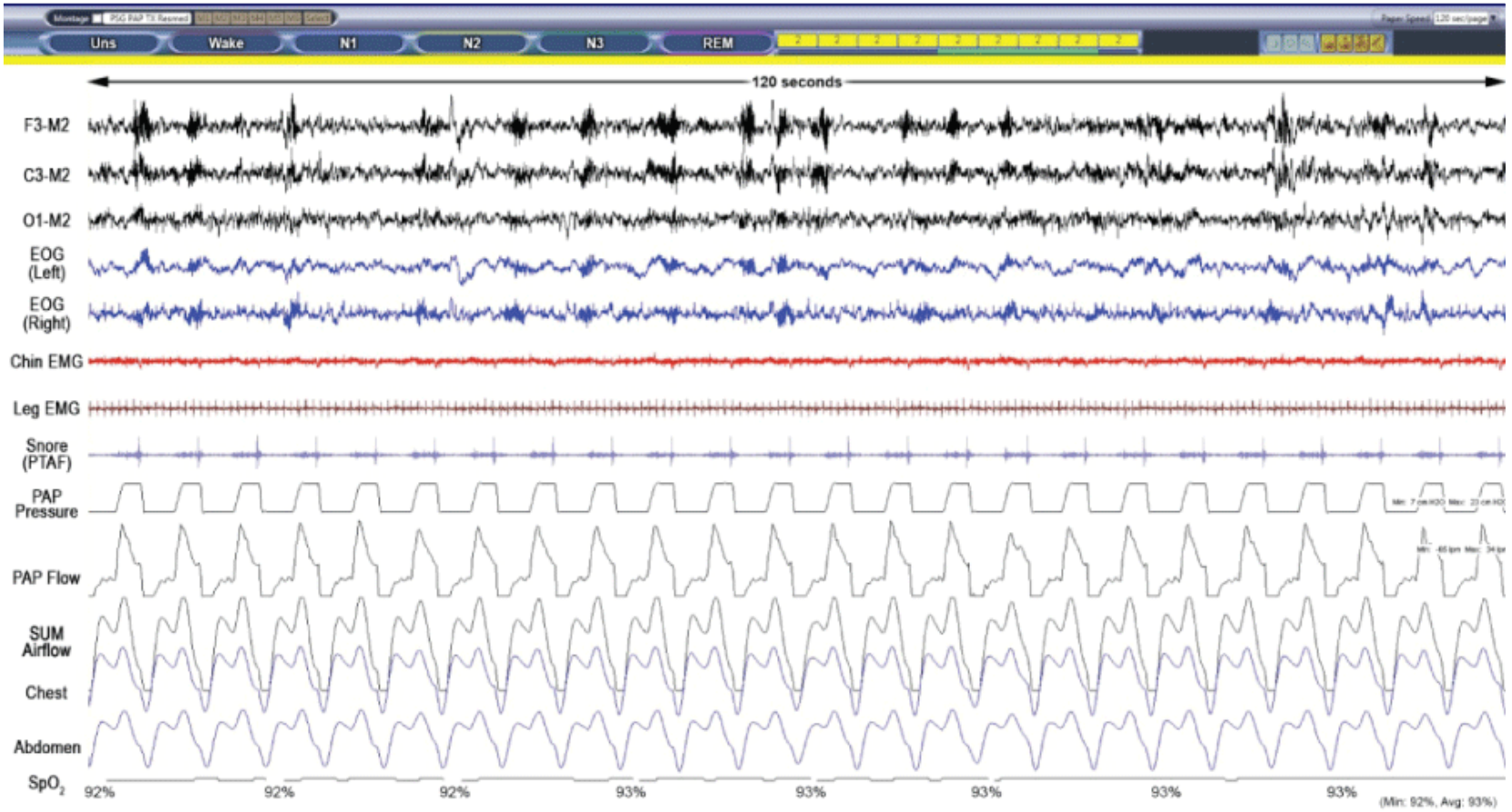
- Decrease response to external stimulation
- Attenuated cognitive function
- Immobility
- Closed eyes
- Quiescence

Physiological

- Electroencephalogram
- (EEG)



https://www.sleep-apnea-guide.com/polysomnogram.html


Uns
Wake
N1
N2
N3
REM
120 seconds
F3-M2
C3-M2
O1-M2
EOG (Left)
EOG (Right)
Chin EMG
Leg EMG
Snore (PTAF)
PAP Pressure
PAP Flow
SUM Airflow
Chest
Abdomen
SpO2
92%
92%
92%
93%
93%
93%
93%
93%
(Min: 92%, Avg: 93%)

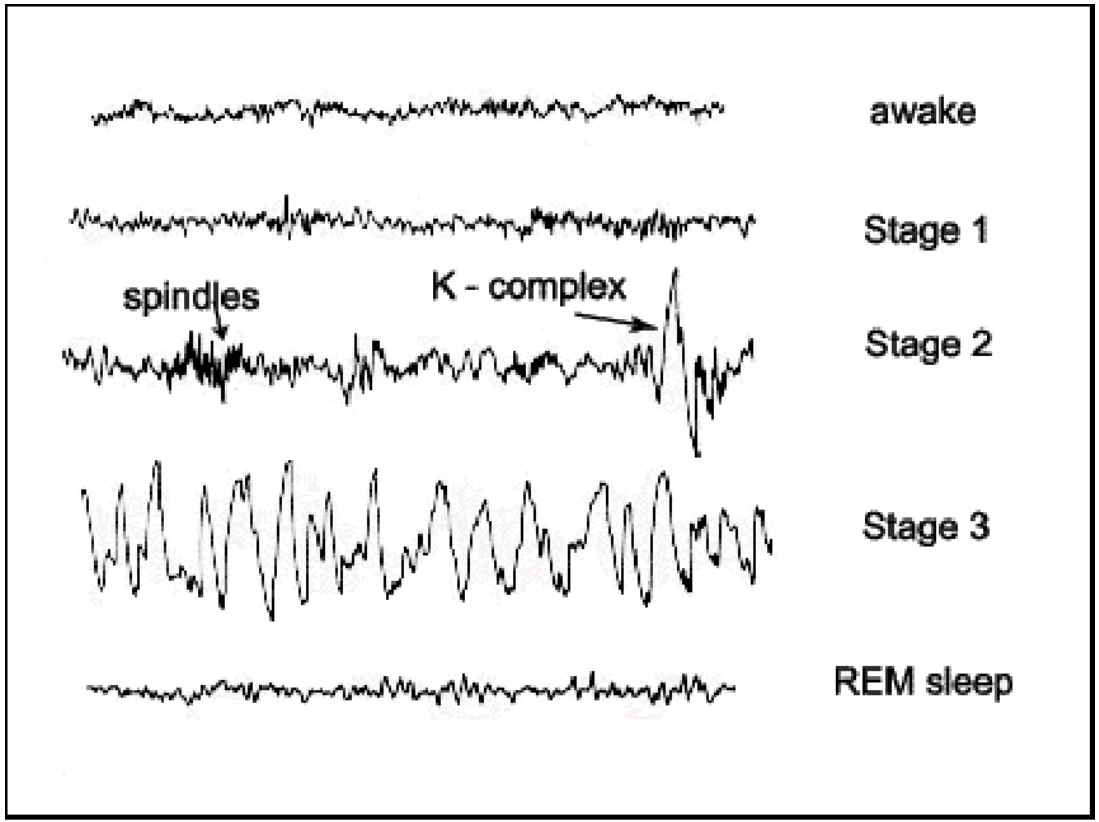
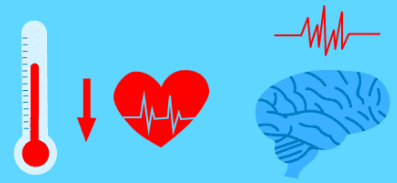


Figure 3: Wave pattern of different sleep Stages


414, R´
4. E1-M2
5. E2-M1
6. RChin-LChi
7. C3-M2
8. C4-M1
9. O1-M2
10. O2-M1
11. ECG

The 4 Stages of Sleep

NREM Stage 1
- transition period between wakefulness and sleep
- lasts around 5 to 10 minutes

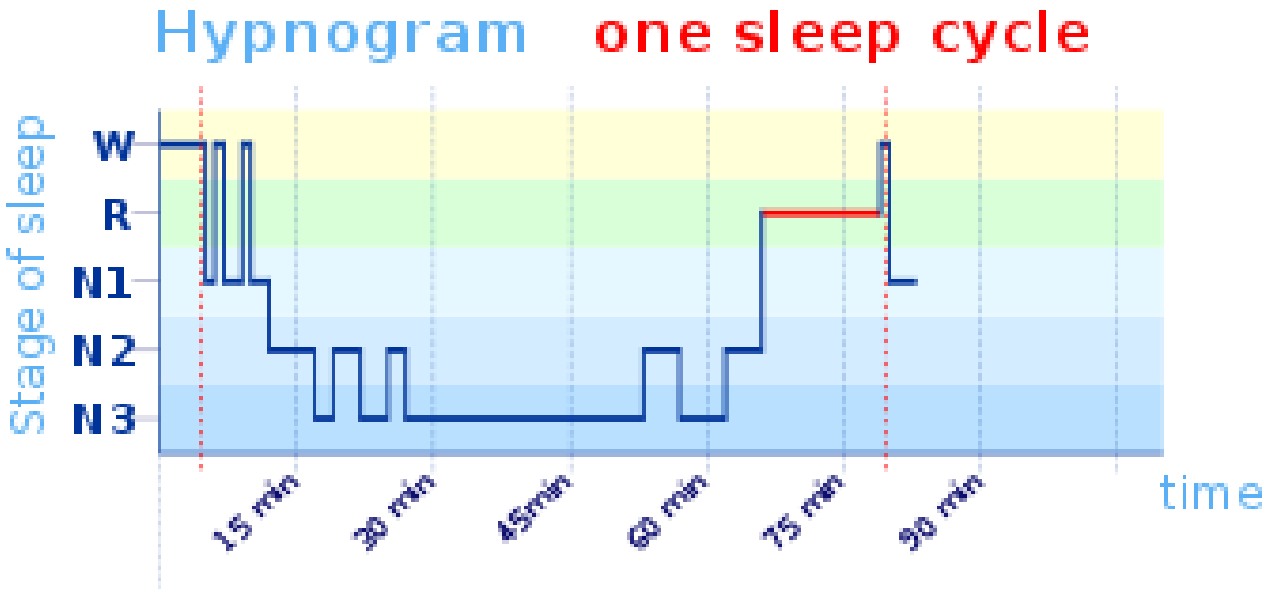


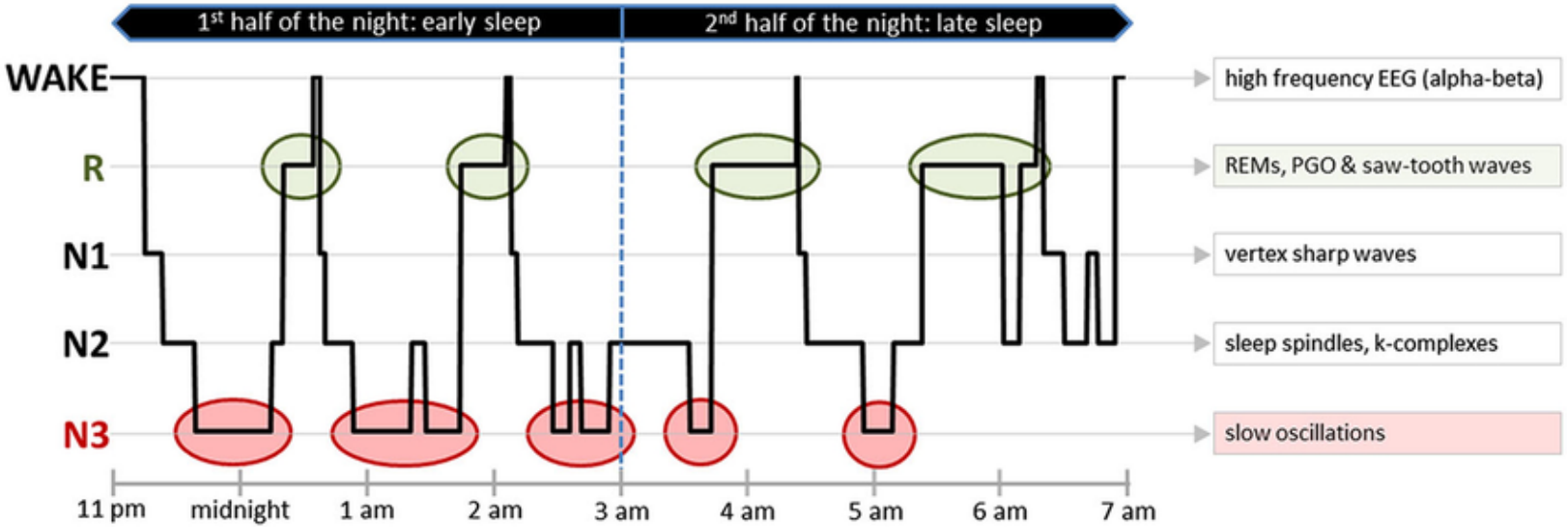
NREM Stage 2
- body temperature drops and heart rate begins to slow
- brain begins to produce sleep spindles
- lasts approximately 20 minutes

NREM Stage 3
- muscles relax
- blood pressure and breathing rate drop
- deepest sleep occurs

REM Sleep
- brain becomes more active
- body becomes relaxed and immobilized
- dreams occur
- eyes move rapidly

verywell


Hypnogram
one sleep cycle
Stage of sleep
W
R
N1
N2
N3
15 min
30 min
45min
60 min
75 min
90 min
time


1st half of the night: early sleep
2nd half of the night: late sleep
WAKE
R
N1
N2
N3
high frequency EEG (alpha-beta)
REMs, PGO & saw-tooth waves
vertex sharp waves
sleep spindles, k-complexes
slow oscillations
11 pm
midnight
1 am
2 am
3 am
4 am
5 am
6 am
7 am

Sleep Stage Function

N1 – Light Sleep

- Slow eye movements
- Easily awoken
- “catnaps”

Sleep Stage Function

N2 – Deeper Sleep

- Sleep Spindles and K-complexes
- Memory

Sleep Stage Function

N3 – Deep Sleep

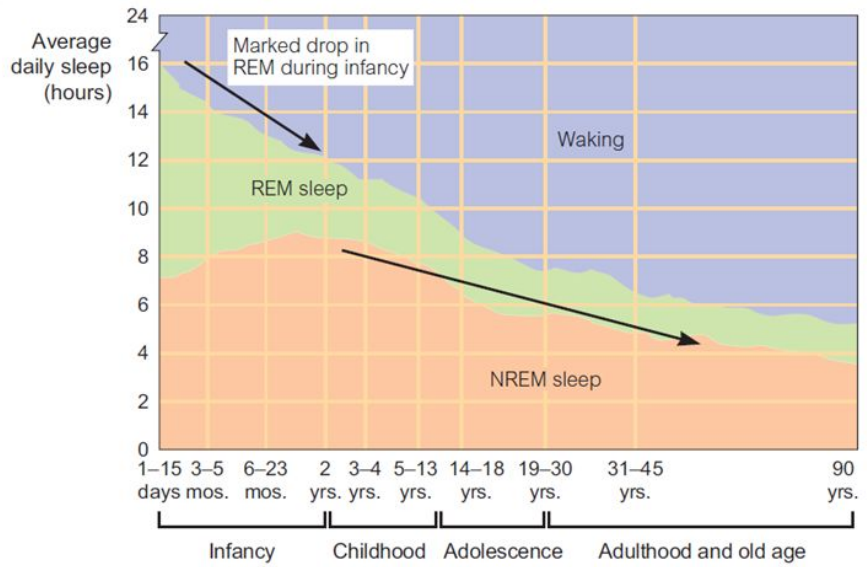
- Difficult to arouse
- Restorative
- Muscle and tissue repair
- Stimulates growth and development
- Boosts immune function

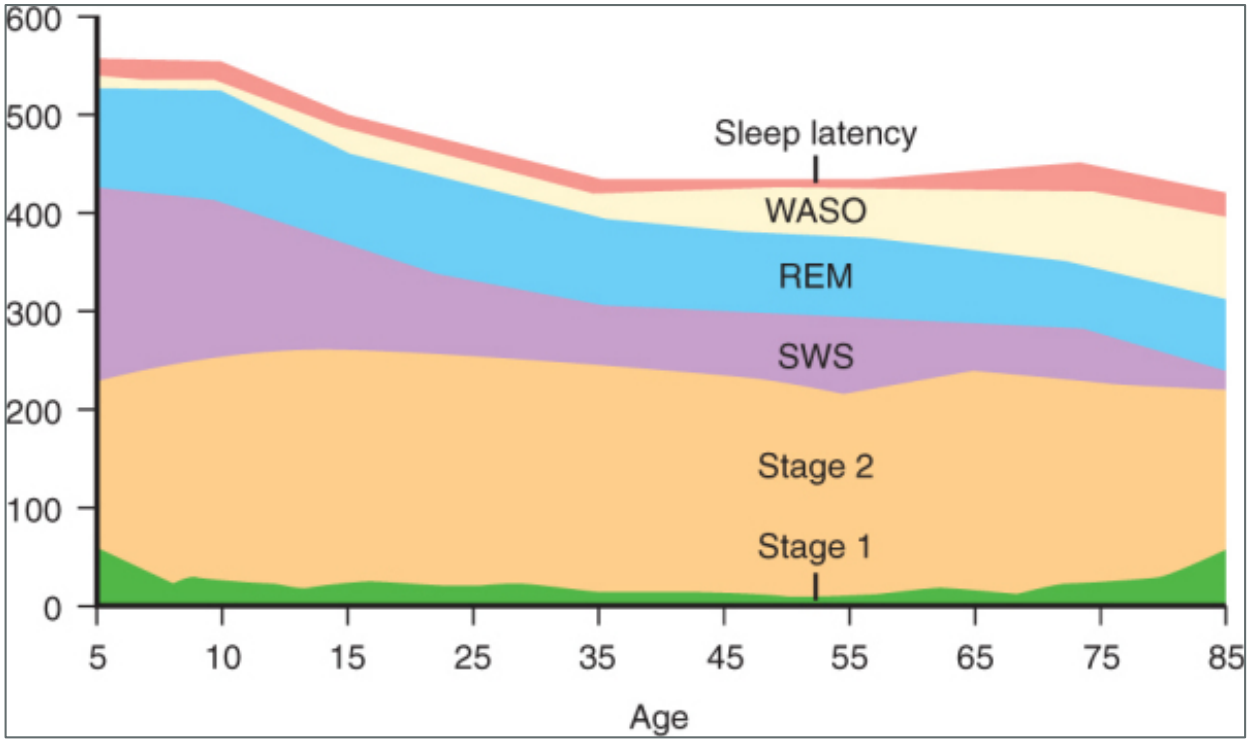
Sleep Stage Function

REM – Dream Sleep

- Increased brain activity
- Processing of memories
- Processing of emotions
- Learning
- Memory consolidation
- Maybe???

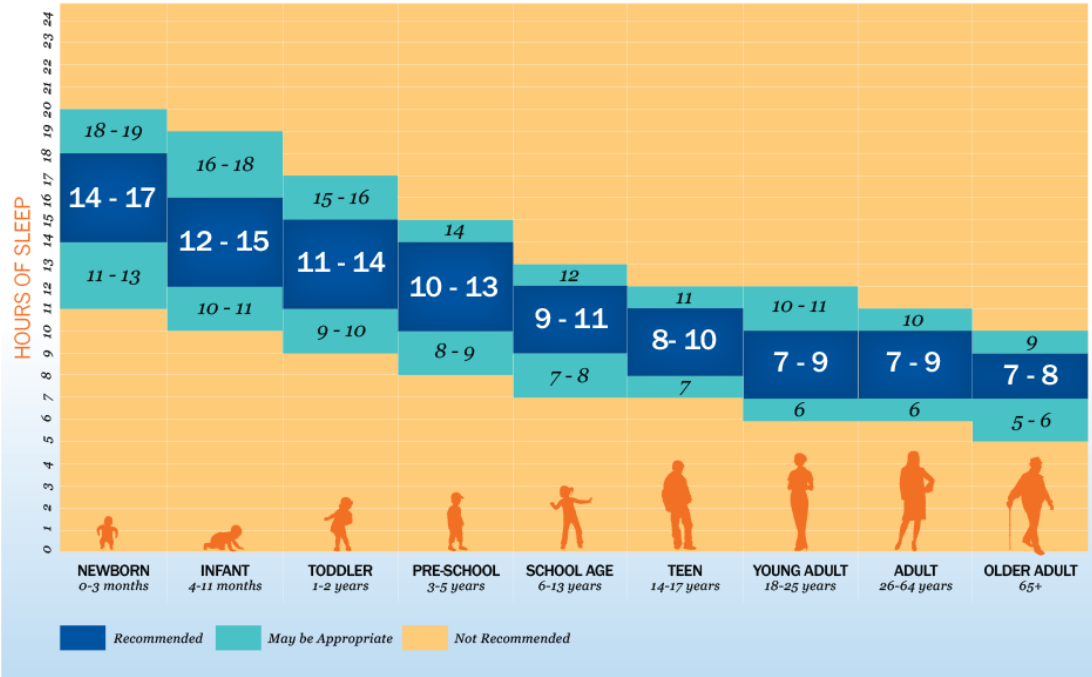
Sleep Through Life




600
500
400
300
200
100
0
Sleep latency
WASO
REM
SWS
Stage 2
Stage 1
5
10
15
25
35
45
55
65
75
85
Age

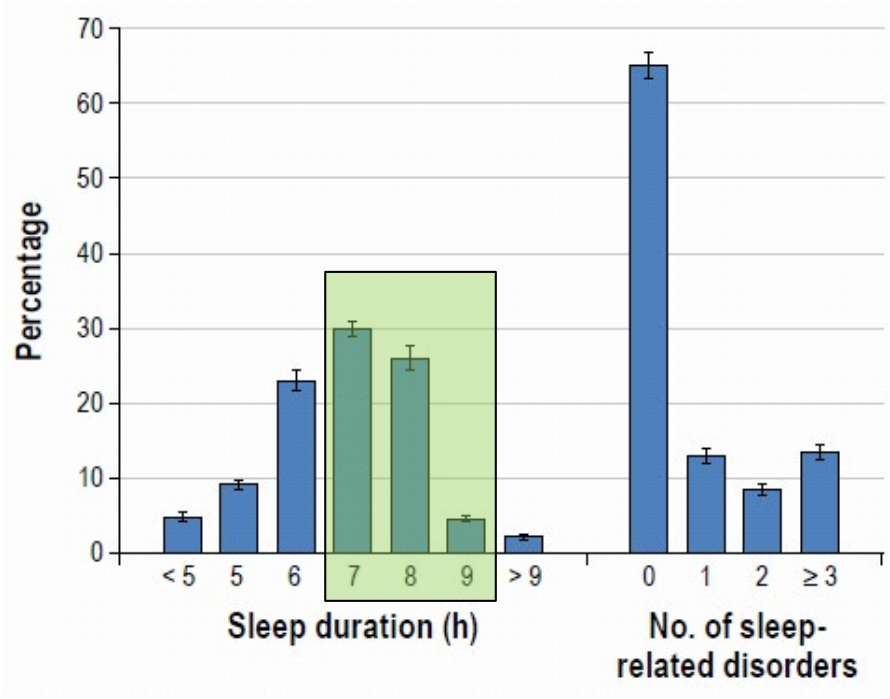
NATIONAL SLEEP FOUNDATION

SLEEP DURATION RECOMMENDATIONS



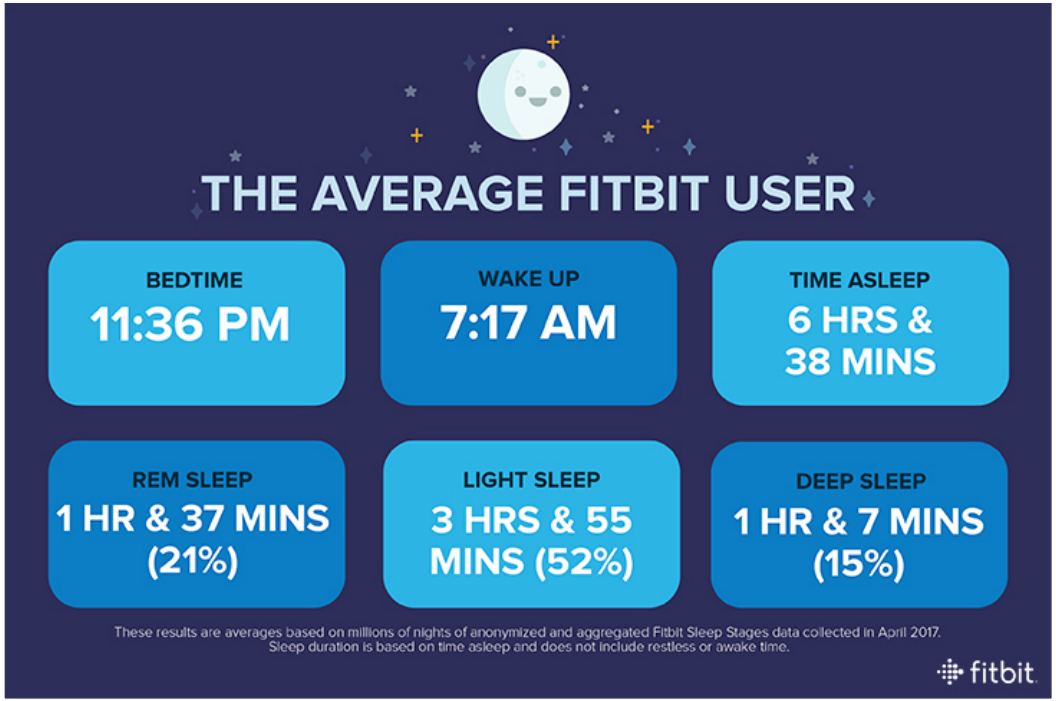
Centers for Disease Control (CDC)

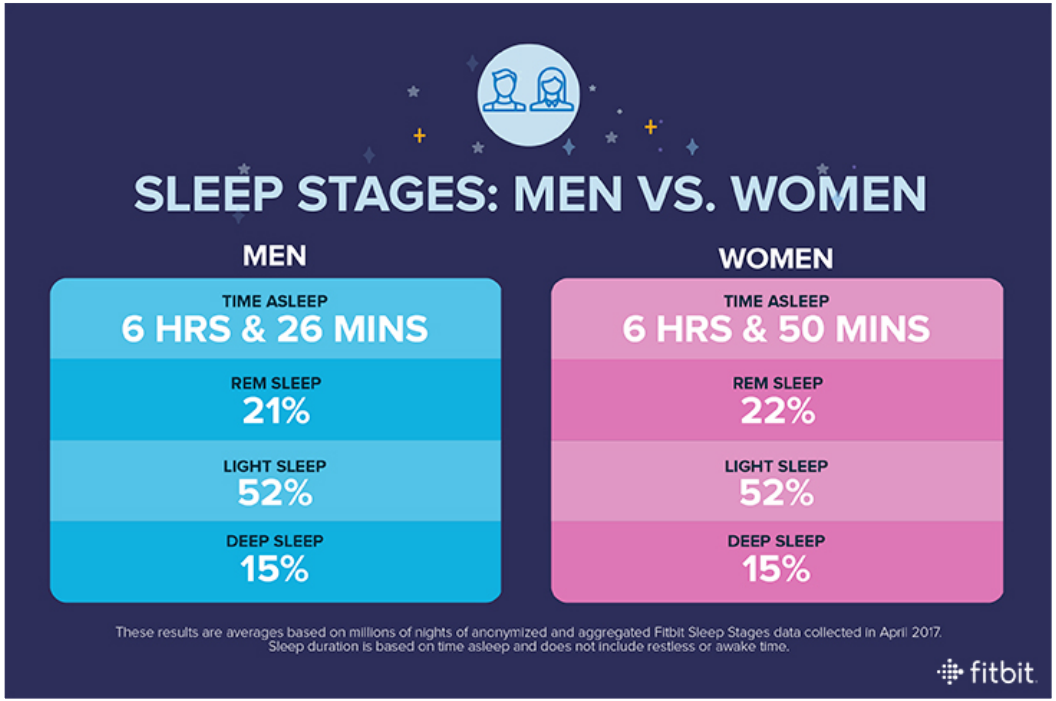
More than a third of American adults are getting less than 7 hours a day of sleep

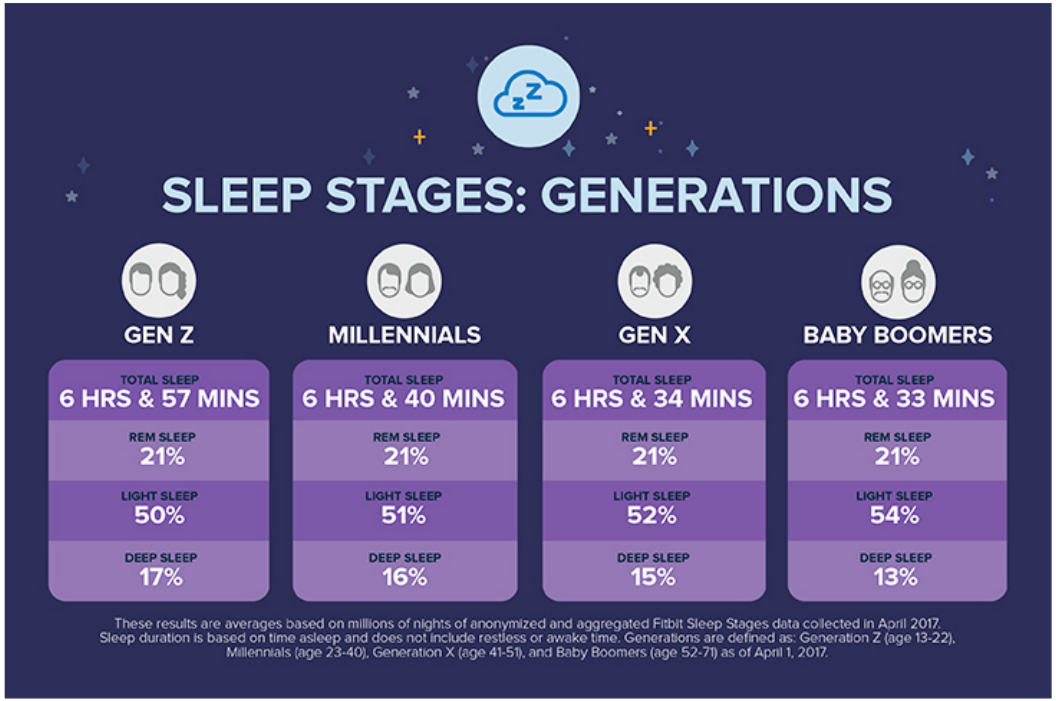


National Health and Nutrition Examination Survey (2005-2006 and 2007-2008)
Luyster S et al. Sleep. 2012 Jun 1;35(6):727-34.

What does Fitbit say?

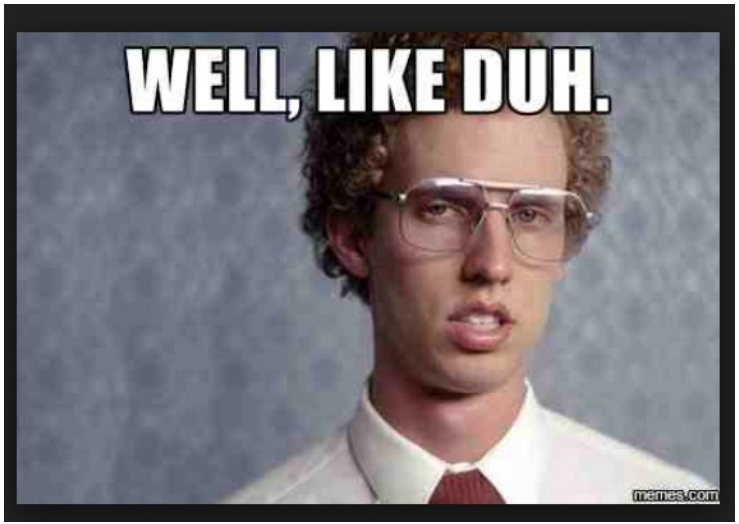

THE AVERAGE FITBIT USER
BEDTIME
11:36 PM
WAKE UP
7:17 AM
TIME ASLEEP
6 HRS & 38 MINS
REM SLEEP
1 HR & 37 MINS (21%)
LIGHT SLEEP
3 HRS & 55 MINS (52%)
DEEP SLEEP
1 HR & 7 MINS (15%)
These results are averages based on millions of nights of anonymized and aggregated Fitbit Sleep Stages data collected in April 2017.
Sleep duration is based on time asleep and does not include restless or awake time.
fitbit


SLEEP STAGES: MEN VS. WOMEN
MEN
TIME ASLEEP
6 HRS & 26 MINS
REM SLEEP
21%
LIGHT SLEEP
52%
DEEP SLEEP
15%
WOMEN
TIME ASLEEP
6 HRS & 50 MINS
REM SLEEP
22%
LIGHT SLEEP
52%
DEEP SLEEP
15%
These results are averages based on millions of nights of anonymized and aggregated Fitbit Sleep Stages data collected in April 2017.
Sleep duration is based on time asleep and does not include restless or awake time.
fitbit

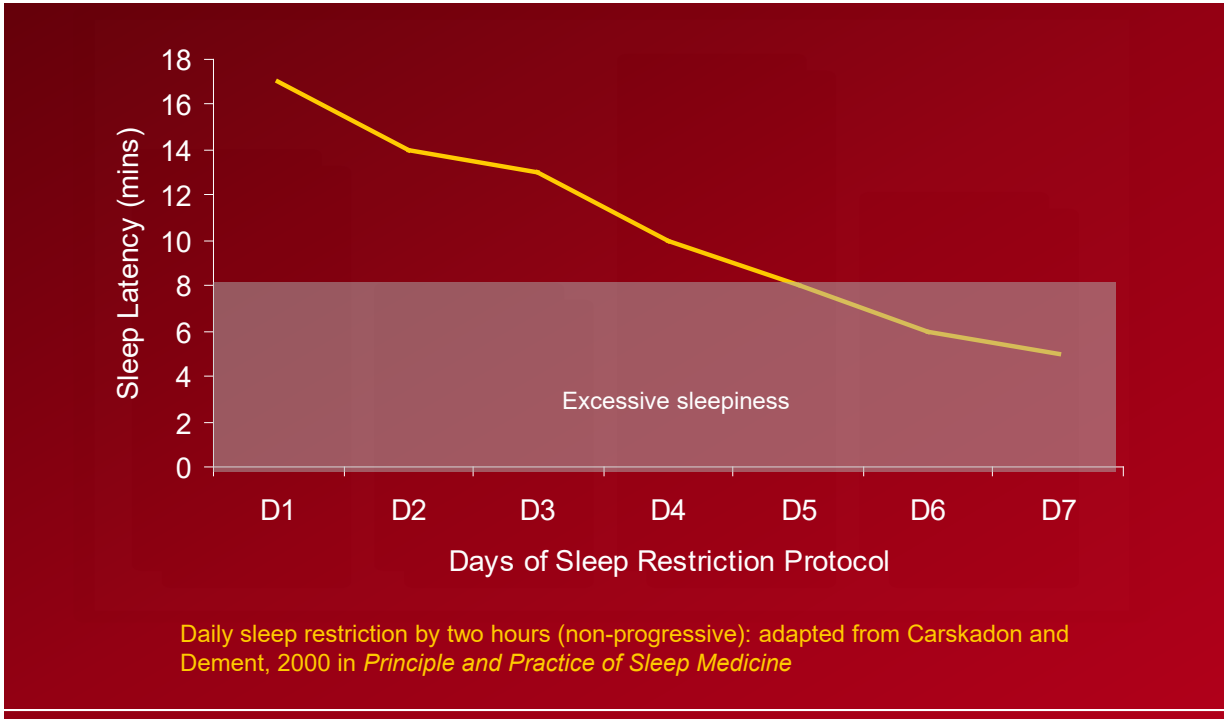

SLEEP STAGES: GENERATIONS
GEN Z
TOTAL SLEEP
6 HRS & 57 MINS
REM SLEEP
21%
LIGHT SLEEP
50%
DEEP SLEEP
17%
MILLENNIALS
TOTAL SLEEP
6 HRS & 40 MINS
REM SLEEP
21%
LIGHT SLEEP
51%
DEEP SLEEP
16%
GEN X
TOTAL SLEEP
6 HRS & 34 MINS
REM SLEEP
21%
LIGHT SLEEP
52%
DEEP SLEEP
15%
BABY BOOMERS
TOTAL SLEEP
6 HRS & 33 MINS
REM SLEEP
21%
LIGHT SLEEP
54%
DEEP SLEEP
13%
These results are averages based on millions of nights of anonymized and aggregated Fitbit Sleep Stages data collected in April 2017.
Sleep duration is based on time asleep and does not include restless or awake time. Generations are defined as: Generation Z (age 13-22), Millennials (age 23-40), Generation X (age 41-51), and Baby Boomers (age 52-71) as of April 1, 2017.

What happens when we are deprived of sleep?

-we get sleepy



Effects of Sleep Debt on Sleep Pressure



Daily sleep restriction by two hours (non-progressive): adapted from Carskadon and Dement, 2000 in *Principle and Practice of Sleep Medicine*

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Science Transl
Vol. 2, Issue 14
DOI: 10.1126/s

Article

Current Biology

Ad libitum Weekend Recovery Sleep Fails to Prevent Metabolic Dysregulation during a Repeating Pattern of Insufficient Sleep and Weekend Recovery Sleep

ss on

and Elizabeth ...

Highlights

- Sleep loss increased after-dinner energy intake and reduced insulin sensitivity
- In total, participants slept an extra 1.1 h during weekend recovery versus baseline
- After-dinner energy intake was reduced during weekend recovery sleep
- Weekend recovery sleep did not prevent weight gain or reduced insulin sensitivity

Authors

Christopher M. Depner, Edward L. Melanson, Robert H. Eckel, ..., Ellen R. Stothard, Sarah J. Morton, Kenneth P. Wright, Jr.

Correspondence

kenneth.wright@colorado.edu

In Brief

Weekend recovery sleep is a common sleep-loss countermeasure. Depner et al. show that short sleep led to later timing of energy intake, weight gain, and reduced insulin sensitivity. Weekend recovery sleep failed to prevent later timing of energy intake, weight gain, or reduced insulin sensitivity during recurrent short sleep following the weekend.

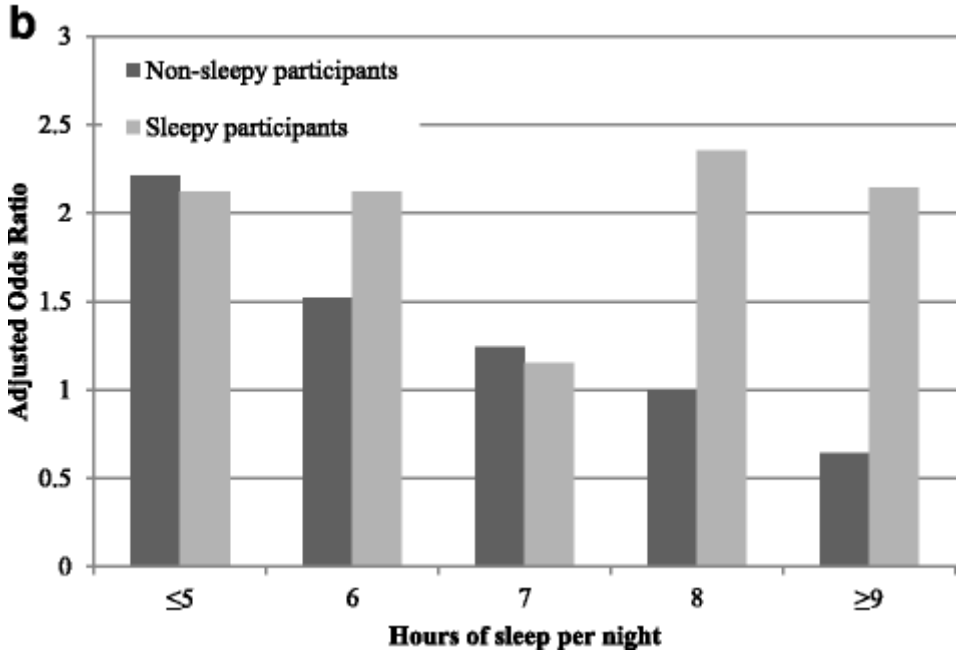
Insufficient Sleep

Personal Safety

Health and Mood

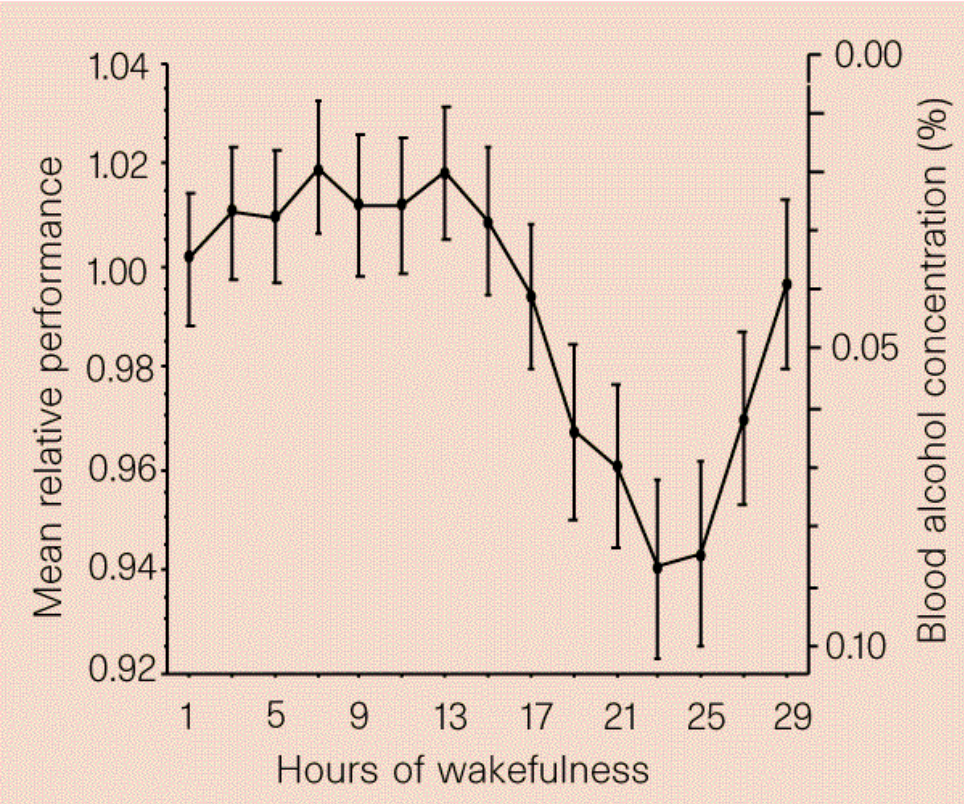
Cognition/Ability to Learn

Driving



- Prospective Cohort with in the Sleep Heart Health Study
- 3201 subjects
- 6 hrs vs 7-8 hrs of sleep
  - 33% increased crash risk
- Independent of self reported sleepiness

https://bmcmedicine.biomedcentral.com/articles/10.1186/s12916-018-1025-7



- 40 subjects
- Kept awake for 28 hours
- Consumed 10-15g alcohol at 30 min intervals
- Computer test of hand-eye coordination

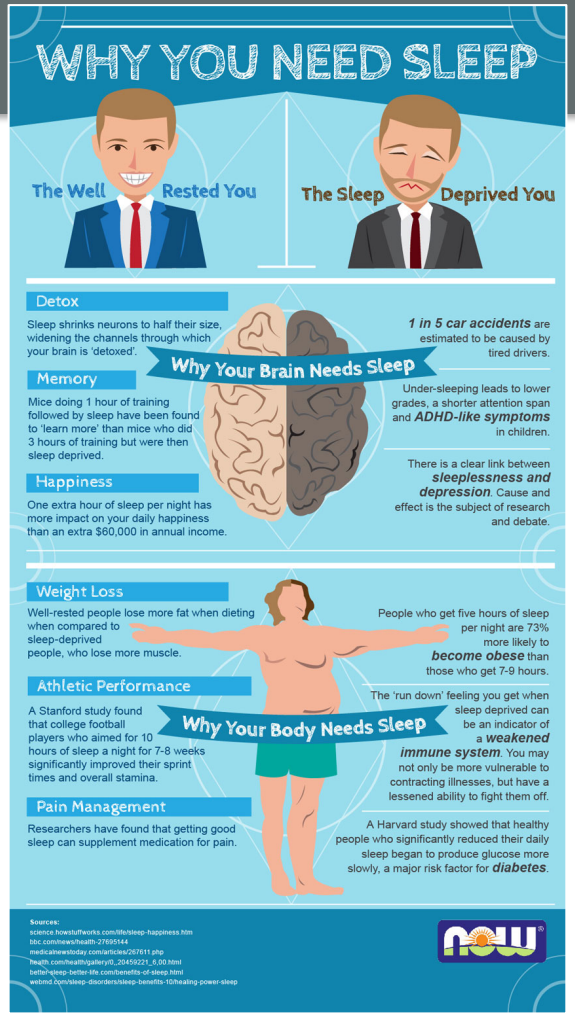
Dawson. Nature 1997

Insufficient Sleep

Personal Safety

Health and Mood

Cognition/Ability to Learn


WHY YOU NEED SLEEP
The Well Rested You
The Sleep Deprived You
Detox
Sleep shrinks neurons to half their size, widening the channels through which your brain is 'detoxed'.
Memory
Mice doing 1 hour of training followed by sleep have been found to 'learn more' than mice who did 3 hours of training but were then sleep deprived.
Happiness
One extra hour of sleep per night has more impact on your daily happiness than an extra $60,000 in annual income.
Why Your Brain Needs Sleep
1 in 5 car accidents are estimated to be caused by tired drivers.
Under-sleeping leads to lower grades, a shorter attention span and ADHD-like symptoms in children.
There is a clear link between sleeplessness and depression. Cause and effect is the subject of research and debate.
Weight Loss
Well-rested people lose more fat when dieting when compared to sleep-deprived people, who lose more muscle.
Athletic Performance
A Stanford study found that college football players who aimed for 10 hours of sleep a night for 7-8 weeks significantly improved their sprint times and overall stamina.
Pain Management
Researchers have found that getting good sleep can supplement medication for pain.
Why Your Body Needs Sleep
People who get five hours of sleep per night are 73% more likely to become obese than those who get 7-9 hours.
The 'run down' feeling you get when sleep deprived can be an indicator of a weakened immune system. You may not only be more vulnerable to contracting illnesses, but have a lessened ability to fight them off.
A Harvard study showed that healthy people who significantly reduced their daily sleep began to produce glucose more slowly, a major risk factor for diabetes.
Sources:
science.howstuffworks.com/life/sleep-happiness.htm
bbc.com/news/health-27695144
medicalnewstoday.com/articles/267611.php
health.com/health/gallery/0,,20459221_6,00.html
better-sleep-better-life.com/benefits-of-sleep.html
webmd.com/sleep-disorders/sleep-benefits-10/healing-power-sleep
now

Sleep Deprivation and Immunity

Decreased Lymphocytes

- CD4
- CD16
- CD56
- CD57

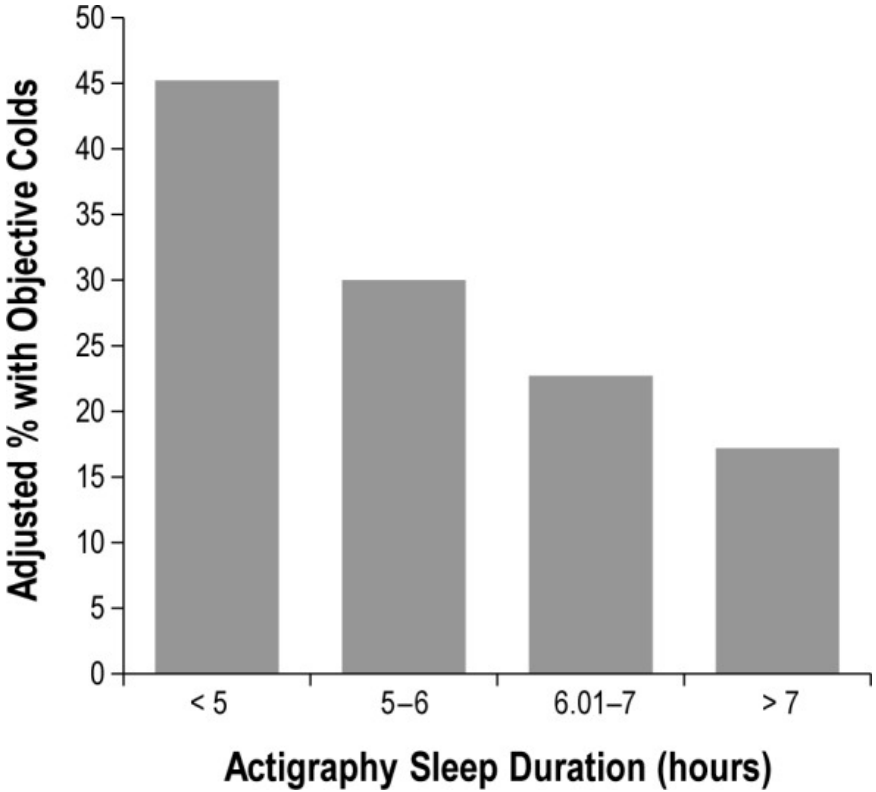
Zager Am J Physiol Regul Integr Comp Physiol. 2007

Sleep Deprivation and Immunity

Increased pro-inflammatory cytokines

- Interleukin 1
- Interleukin 6
- C-reactive protein
- Tumor Necrosis Factor (TNF) α

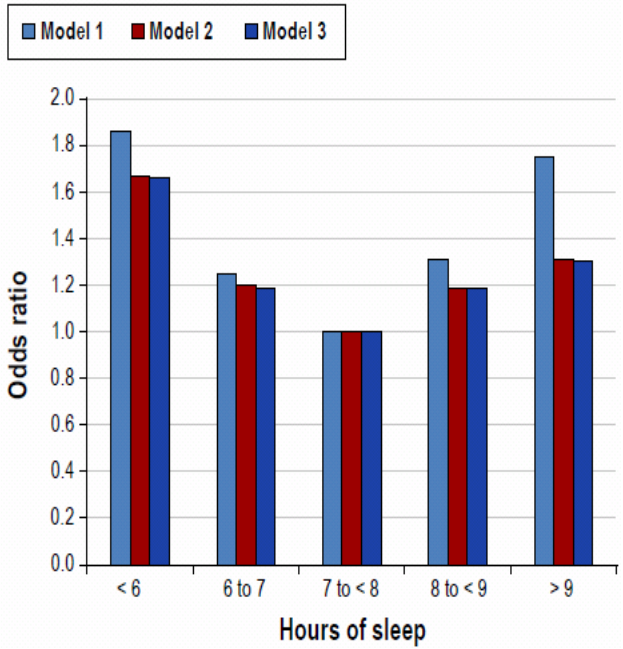
Zager Am J Physiol Regul Integr Comp Physiol. 2007



- 164 Healthy subjects
- 7 days of wrist actigraphy
- Quarantined
- Exposed to rhinovirus

Prather AA et al. Sleep. 2015 Sep 1;38(9):1353-9

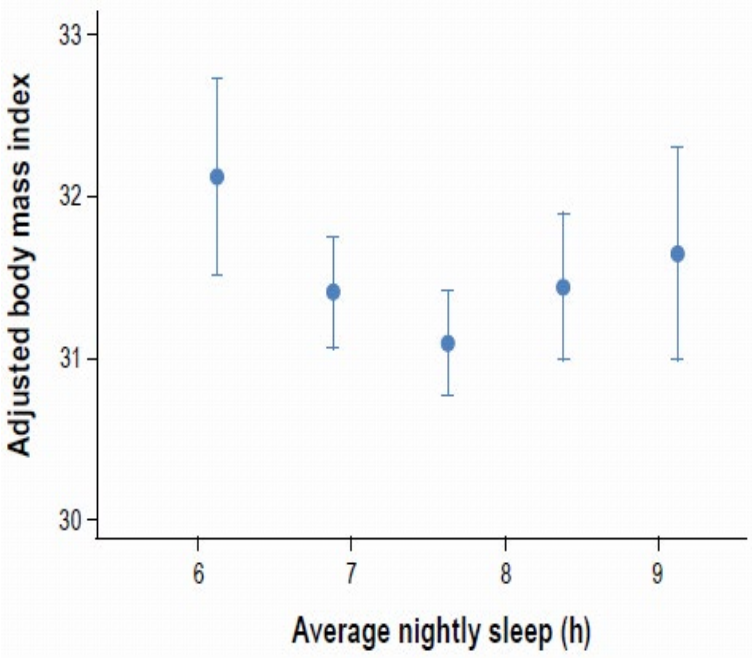
Sleep Deprivation and Hypertension



- **Model 1 – unadjusted**
- **Model 2 – adjusted for age, sex, race and AHI**
- **Model 3 – adjusted for age, sex, race, AHI, and BMI**

Luyster S et al. Sleep. 2012 Jun 1;35(6):727-34.

Sleep Deprivation and Obesity



- **Sleeping more or less than 7.7 hours associated with increased BMI**

Adapted from : Taheri S et al. PLoS Med 2004;1:e62
Luyster S et al. Sleep. 2012 Jun 1;35(6):727-34.
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Sleep Deprivation and Depression

	Depression at Wave 1			
	Crude OR, 95% CI		Adjusted* OR, 95% CI	
Sleep Deprivation at Wave 1	Major Depression	Depression Symptoms	Major Depression	Depression Symptoms
Short Sleep WN/WE	3.86† (2.28-6.54)	1.56† (1.31-1.85)	3.79† (2.21-6.50)	1.42† (1.17-1.71)
Short Sleep WN	2.84† (1.50-5.41)	1.69† (1.31-2.17)	2.80† (1.42-5.50)	1.55† (1.19-2.02)

Depression Symptoms = Depressed mood, anhedonia, or irritable mood. Short Sleep WN/WN = Sleep ≤ 6 h on weeknights and weekends. Short Sleep WN = Sleep ≤ 6 h on weeknights. *Adjusting for age, gender, and family income. †Odds ratios are statistically significant (P < 0.05).

	Depression at Wave 2			
	Crude OR, 95% CI		Adjusted* OR, 95% CI	
Sleep Deprivation at Wave 1	Major Depression	Depression Symptoms	Major Depression	Depression Symptoms
Short Sleep WN/WE	4.58† (2.36-8.86)	1.39† (1.14-1.68)	3.12† (1.55-6.27)	1.25† (1.01-1.54)
Short Sleep WN	5.21† (2.48-10.93)	1.56† (1.19-2.05)	3.76† (1.65-8.58)	1.38† (1.02-1.85)

Depression Symptoms = depressed mood, anhedonia, or irritable mood. Short Sleep WN/WN = Sleep ≤ 6 h on weeknights and weekends. Short Sleep WN = Sleep ≤ 6 h on weeknights. *Adjusting for age, gender, family income, and depression (either major depression or symptoms at Wave 1. †Odds ratios are statistically significant (P < 0.05).

- **3134 youths age 11-17 years old**
- **Reduced quantity of sleep increases risk for major depression, which in turn increases risk for decreased sleep**

Roberts et al. Sleep. 2014 (37):239-244

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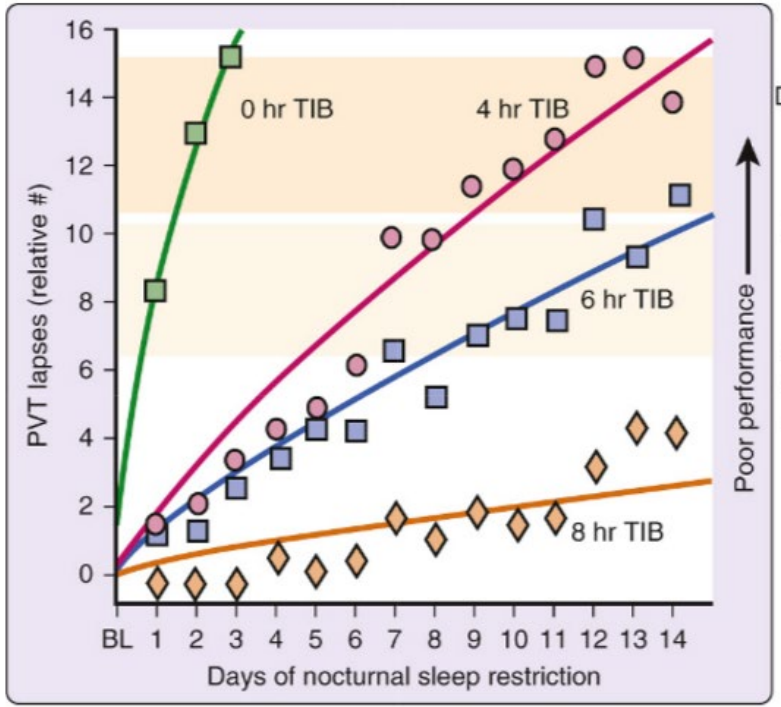
Insufficient Sleep

Personal Safety

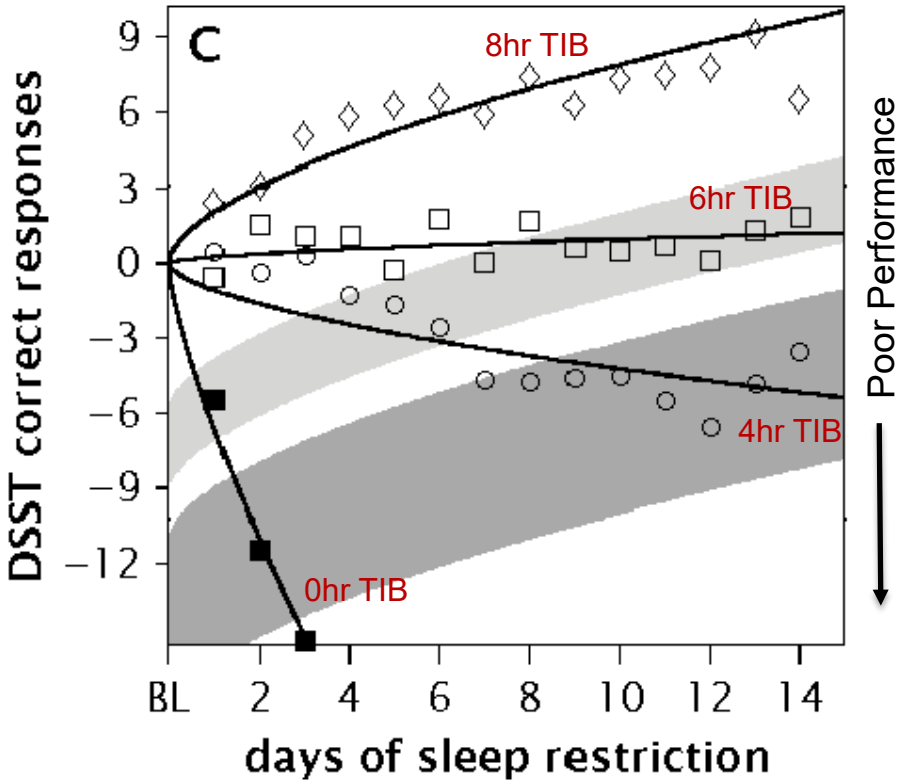
Health and Mood

Cognition/Ability to Learn



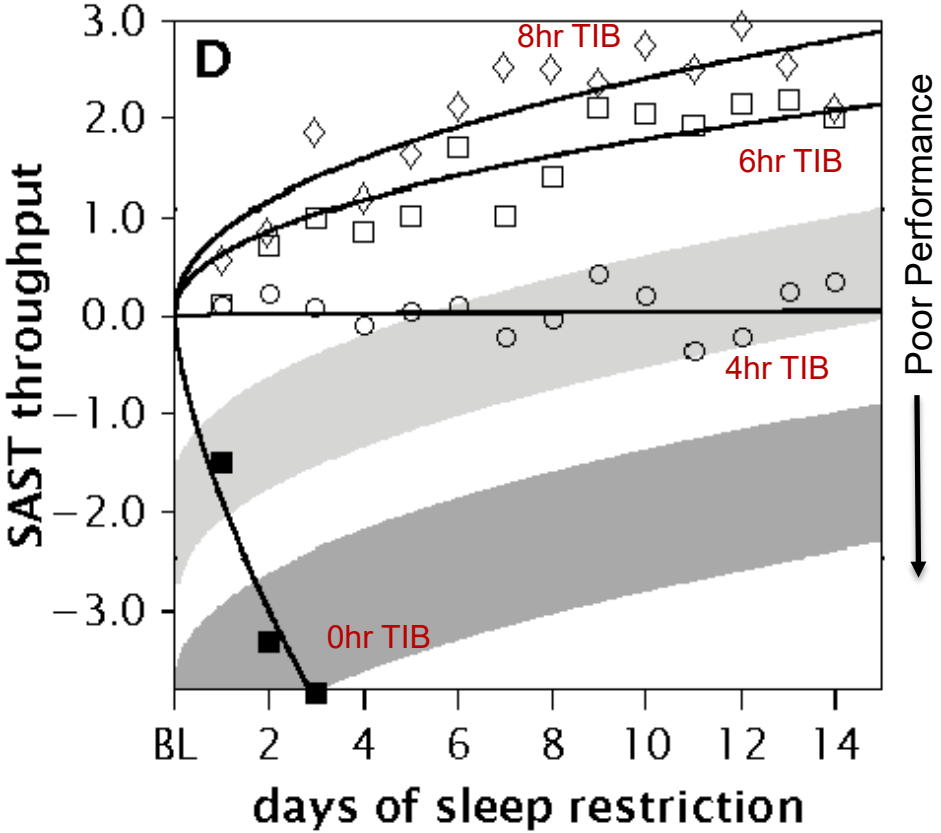
- **48 healthy adults (ages 21-38)**
- **Psychomotor Vigilence Test – measure of behavioral alertness**
- **Effects are cumulative – 14 nights of 4 hr equivalent to 2 nights of total sleep deprivation**

Van Dongen et al. *Sleep* 2003;26:117-26
(image from Principles and Practice 6th ed.)



- **Digit Symbol Substitution Task– measure of processing speed, working memory, visuospatial processing and attention.**

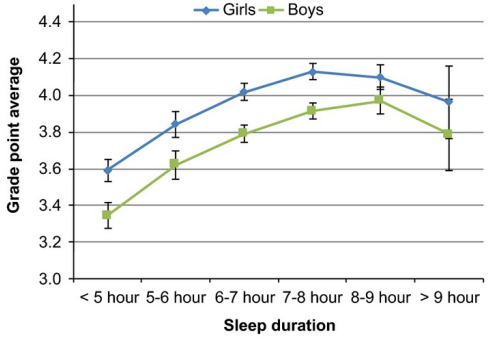
Van Dongen et al. *Sleep* 2003;26:117-26

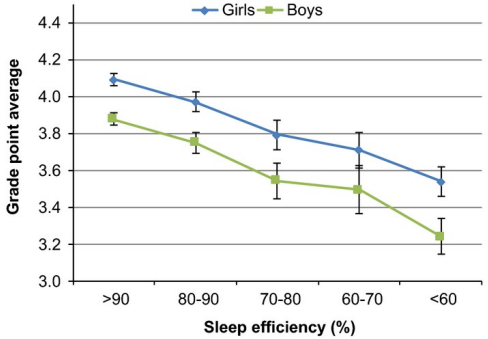


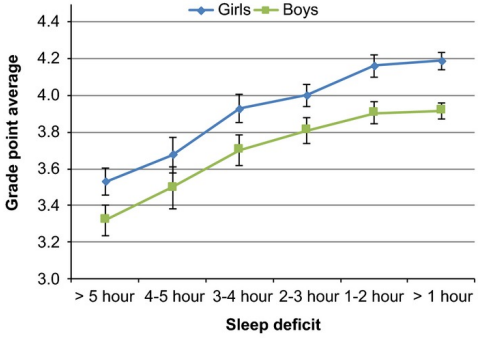
- **Serial addition/subtraction task– measure of cognitive throughput.**

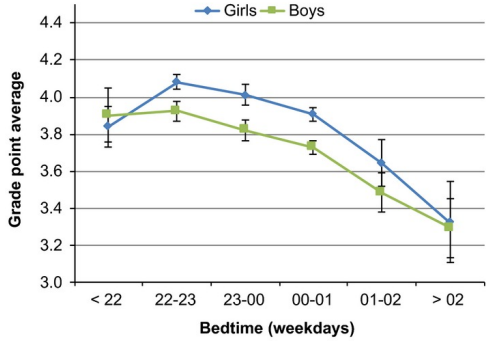
Van Dongen et al. *Sleep* 2003;26:117-26

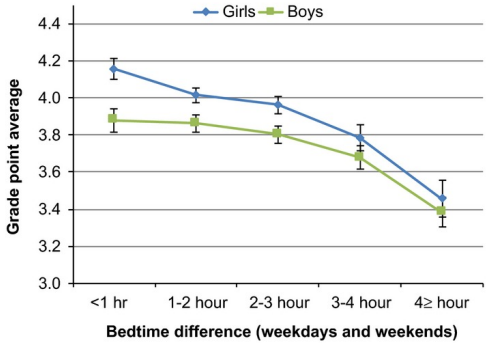
Association between short sleep duration and lower academic performance



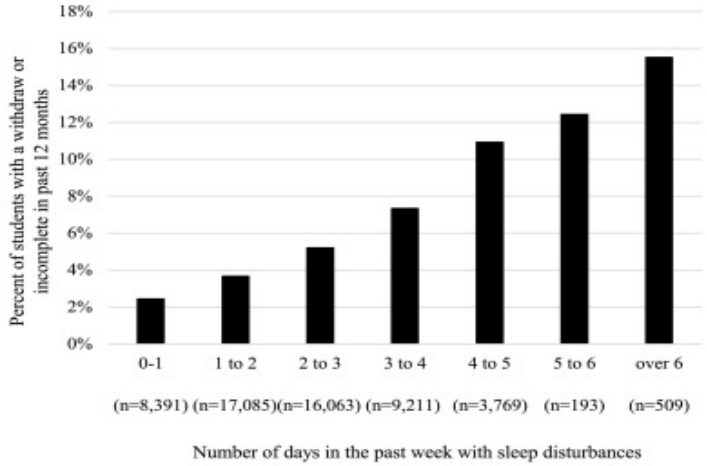


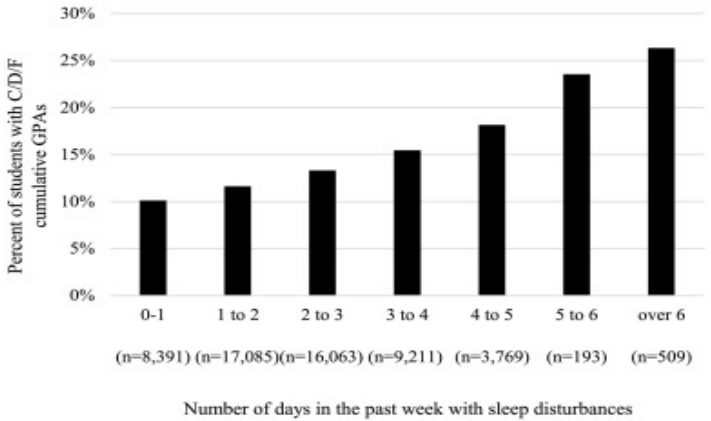






Hysing M, Harvey AG, Linton SJ, Askeland KG, Sivertsen B. J **Sleep** Res. 2016 Jun;25(3):318-24. doi: 10.1111/jsr.12373.





Each additional day per week that a student (N=55,322) experienced sleep problems

- Increased probability of dropping a course by 10%
- Lowered cumulative GPA 0.02

Hartmann ME, Prichard JR. Calculating the contribution of sleep problems to undergraduates' academic success. Sleep Health. 2018 Oct;4(5):463-471.

How do we improve sleep?

Prioritizing

Sleep Hygiene

Minimizing Screen time

Consider Adolescent Sleep-Wake Cycle

Stimulus Control

Relaxation Techniques

Prioritizing

Setting aside enough time to sleep

Attending to things that hurt / help sleep

Sleep hygiene

Maintaining a regular sleep schedule

Bedtime routine

Sleep environment

- Cool (60-70°F)
- Dark
- Quiet or
- White noise

Sleep hygiene

Regular exercise, but not too close to bedtime

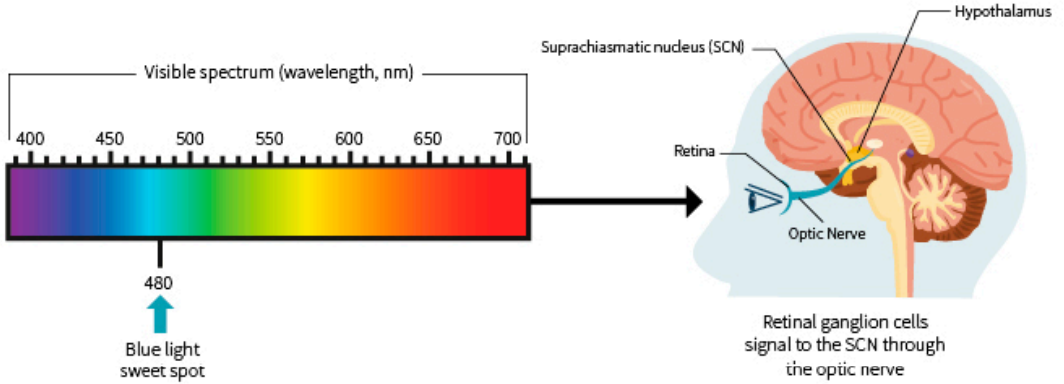
Limit naps

Limit caffeine, alcohol, and smoking/nicotine

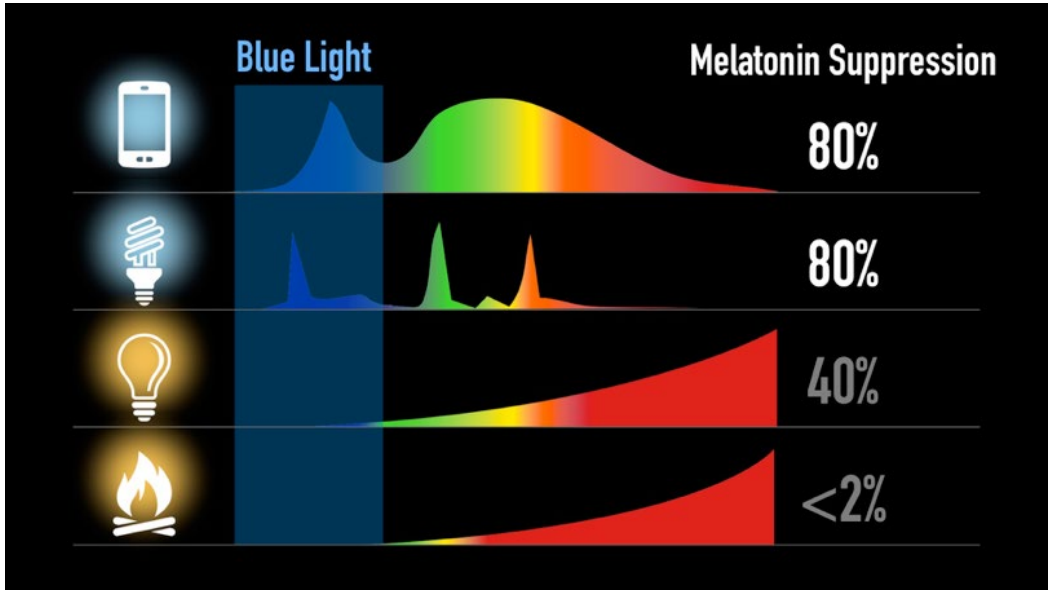
Hide clocks

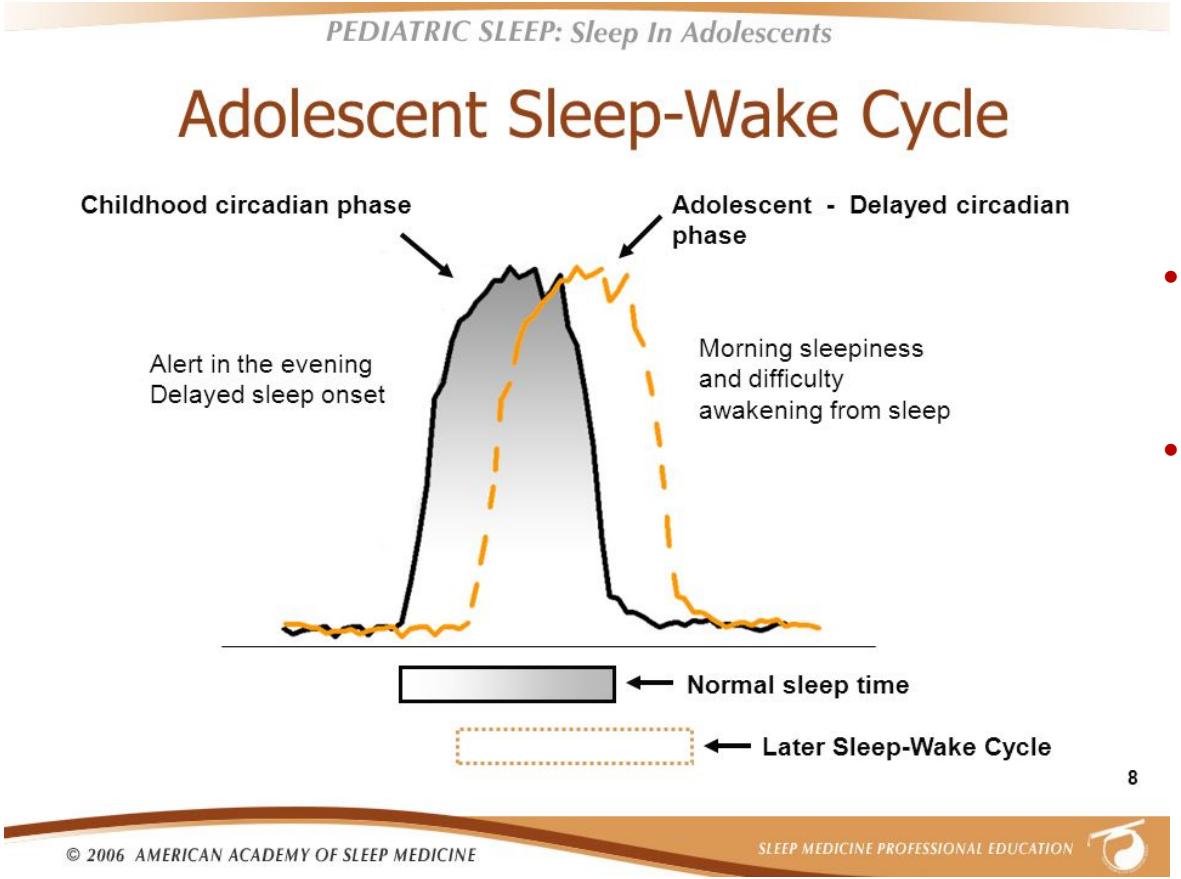
Screen Time/Blue Light

Figure xx - Visible spectrum and path to the SCN



Screen Time/Blue Light





- **Evident in different cultures**
- **Maximum shift**
  - **Around Age of 20**

Colrain IM. Baker FC. Changes in sleep as a function of adolescent development. Neuropsychol Rev. 2011;21:5–21.


SLEEP SCHEDULES
GEN Z
BEDTIME
12:08 AM
WAKE UP
8:12 AM
MILLENNIALS
BEDTIME
11:45 PM
WAKE UP
7:28 AM
GEN X
BEDTIME
11:25 PM
WAKE UP
7:00 AM
BABY BOOMERS
BEDTIME
11:17 PM
WAKE UP
6:53 AM
These results are averages based on millions of nights of anonymized and aggregated Fitbit Sleep Stages data collected in April 2017. Generations are defined as: Generation Z (age 13-22), Millennials (age 23-40), Generation X (age 41-51), and Baby Boomers (age 52-71) as of April 1, 2017.

School Start Times, Sleep, Behavioral, Health, and Academic Outcomes: a Review of the Literature

Anne G. Wheaton, PhD, Daniel P. Chapman, PhD, and Janet B. Croft, PhD

Author information Copyright and License information Disclaimer

Delaying school start time

Increases weeknight sleep duration

Improved attendance

Less tardiness

Less falling asleep in class

Better grades

Fewer motor vehicle crashes

American Academy of Pediatrics (2014) Recommendations

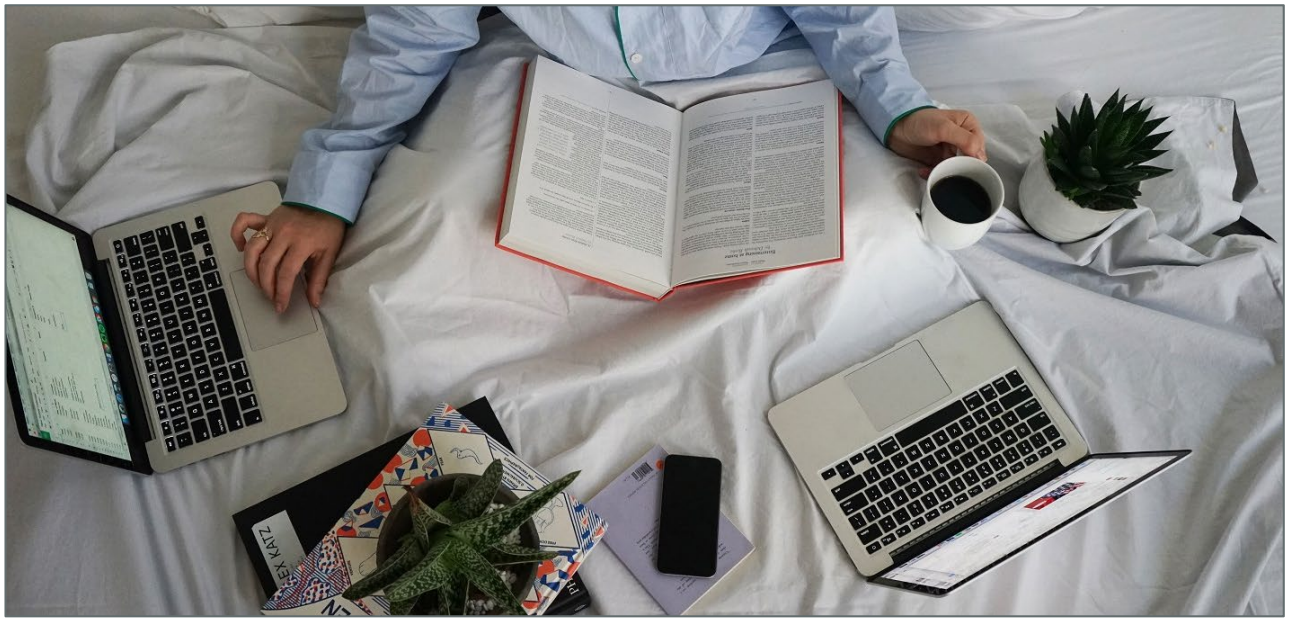
8.5-9.5 hours of sleep

Community education

School start time no earlier than 8:30am

Adolescent Sleep Working Group; Committee on Adolescence; Council on School Health. School start times for adolescents. Pediatrics. 2014 Sep;134(3):642-9.

Stimulus Control



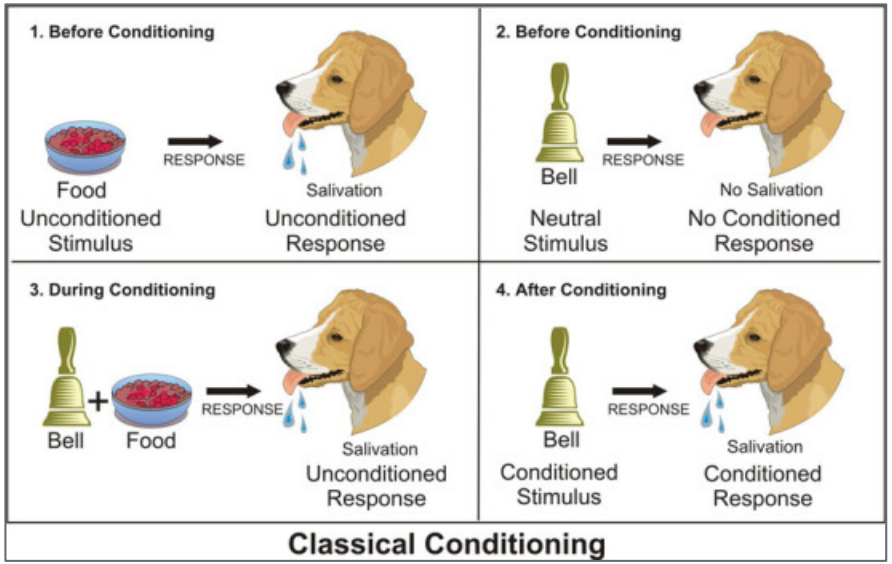
Stimulus Control

Strengthening association of the bed and sleep

Increasing sleep efficiency

Stimulus Control

- Using the bed only for sleep
- Going to bed only when sleepy
- Getting out of bed when unable to sleep



Relaxation Techniques

Progressive Muscle Relaxation

Imagery

Diaphragmatic breathing

Mindfulness Meditation

Tai chi / Yoga

Take Home

- Sleep is important
- Sleep deprivation impacts safety, health, mood and cognition
- We can improve sleep by
  - Prioritizing sleep,
  - Maintaining good sleep hygiene,
  - Limiting screen time
  - Consider adolescent circadian shifts
  - Stimulus control
  - Relaxation techniques